

AMERICAN SOCIETY OF HEATING, REFRIGERATING**AND AIR-CONDITIONING ENGINEERS, INC.****1791 Tullie Circle, NE Atlanta, GA 30329 404-636-8400****TC/TG/TRG MINUTES COVER SHEET****(Minutes of all meetings are to be distributed to all persons listed below****within 60 days following the meeting.)****TC/TG/TRG NO. TC4.11 DATE: 25 January 2000****TC/TG/TRG TITLE: Smart Building Systems****DATE OF MEETING: 22 June 99 LOCATION: Seattle**

Members Present	Appt	Members Absent	Appt	Ex-Officio Members and Additional Attendance
Jim Braun	99-01	Arthur Dexter (int'l member)	96-00	Osman Ahmed
Todd Rossi	99-03	Jeff Haberl	98-02	J. R. Anderson
John Mitchell	96-00	Doug Nordham	96-00	Michael Brambley
Michael Kintner-Meyer	99-03	Patrick O'Neill	96-99	Mike Brandemuehl

Carol Lomonaco	96-99	Mark Bailey (CM)	98-	Marty Burns
Philip Haves (int'l member)	96-00	Dale Hitchings		Richard Buswell
Rich Hackner	98-02	Kirk Drees (CM)	96-	David Callan
John House	99-03	Tom Engbring (CM)	99-	Manny D'Albora
Steve Blanc	99-03	Ira Goldschmidt (CM)	98-	Ken Gillespie
Mark Breuker	99-03	Ron Nelson (CM)	98-	Michael He
Barry Bridges	98-02	Barry Reardon (CM)	99-	Srinivas Katipamula
James Gartner	98-02	Tim Ruchti (CM)	96-	Satkartar Khalsa
Les Norford (CM)	99-	Greg Schoenau (CM)	96-	Kris Kinney
George Kelly (CM)	99-	Peter Simmonds (CM)	98-	Ian McIntosh
Natascha Castro (CM)	99-	Meli Sylianou (CM)	99-	Bob Old
J. Carlos Haiad (CM)	96-			Ofer Pittel
David Kahn (CM)	96-			Rob Pratt

Brian Kammers (CM)	96-			Agami Reddy
Curt Klaassen (CM)	99-			John Scott
John Seem (CM)	99-			Pornsak Songkakul
Jim Winston (CM)	96-			Jonathan West
				Jonathan Wright
				Jiong Zhou

DISTRIBUTION:**ALL MEMBERS OF TC/TG/TRG****TAC CHAIRMAN: Terry Townsend****TAC SECTION HEAD: Byron Jones****ALL COMMITTEE LIASONS AS SHOWN ON TC/TG/TRG ROSTERS:****Program: Emil E. Friberg Manager Of Technical Services: Martin J. Weiland****Research: Carl F. Speich Manager Of Research: William W. Seaton****Standards: Waller S. Clements Manager Of Standards: Claire B. Ramspeck****Journal: Kelley Cramm****ADDITIONAL DISTRIBUTION: Visitors listed above**

ASHRAE TC ACTIVITIES SHEET**DATE: 25 January 2000****TC NO. TC4.11 TC TITLE: Smart Building Systems****CHAIR: J. Braun VICE CHAIR: J. Mitchell****TC Meeting Schedule**

Location, past 12 mo.	Date	Location, next 12 mo.	Date
Chicago	1/26/99	Dallas	2/8/00
Seattle	6/22/99	Minneapolis	6/27/00

TC Subcommittees

Subcommittee	Chair
Technology Development	T. Rossi
Communications and Integration	M. Kintner-Meyer
Testing and Evaluation	J. House
Research	G. Kelly

Program	C. Lomonaco
Standards	R. Hackner
Handbook	M. Bailey

Research Projects

1011-RP Utility/EMCS Communication Protocol Requirements (Final Report approved by TC 4.11 at Seattle Annual Meeting, June 22, 1999)

1020-RP Demonstration of Fault Detection and Diagnostic Methods in a Real Building

1043-RP Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers

1139-RP Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment (Contractor recommended by TC 4.11 to RAC at Seattle Annual Meeting, June 22, 1999; subsequently, RAC and Tech Council approved the recommended contractor, Drexel University)

Long Range Research Plan (as approved by TC 4.11 at the Seattle Annual Meeting)

Rank	Title	W/S Written ?	TC Approved ?	To RAC ?
1	Evaluation of Existing Fault Detection and Diagnostic Methods for Chillers	Yes (1 st draft)	No	No
2	Integrated Control for Building Services ¹	No	No	No

3	Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems	Yes (1 st draft)	No	No
4	Prototyping and Field Testing of Utility-Consumer Information Services	Yes (1 st draft)	No	No
5	Quantifying the Benefits of Fault Detection and Diagnostics	No ²	No	No
6	Development of Fault Detection and Diagnostics for Sensor Failures	No ²	No	No
7	Multi-Application Comparison of FDD Methods	No ²	No	No

1. A work statement for Integrated Control for Building Services was approved by TC 4.11 and RAC and designated 1146-TRP, but the TRP was rejected by Technology Council. TC 4.11 will rewrite the work statement.
2. One-page project descriptions have been written.

Handbook Responsibilities - none

Standards Activities - none

Technical Papers from Sponsored Research - none

TC Sponsored Symposia (past 3 years, present, planned)

Title	Date (Given or Planned)
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HVAC System Fault Detection And Diagnosis (Kelly)	Philadelphia, 1/97
Controlling Outdoor Air Ventilation for 62-1989 (Atkinson; TC 1.4 lead with TC4.11 as co-sponsor)	Toronto, 6/98
Fault Detection and Diagnostics - Learning from Building Operations (Ahmed; TC4.6 lead with TC4.11 as co-sponsor)	Chicago, 1/99
FDD Methods and Evaluation Techniques (Castro)	Chicago, 1/99

TC Sponsored Seminars (past 3 years, present, planned)

Title	Date (Given or Planned)
The Utility/Building Interface: Redefining an Old Relationship (Blanc)	Boston, 6/97
BACnet in the Real World (Bushby; TC 1.4 lead with SSPC 135 BACnet and TG4.SBS as co-sponsors)	Boston, 6/97
Automated Response To Real Time Pricing (Kammerud)	San Francisco, 1/98
The Delivery of New Energy Services under Electric Industry Deregulation (Nordham; TC4.11 lead with TC 1.4 as co-sponsor)	San Francisco, 1/98

Benefits of Integrating HVAC with Non-HVAC Systems (Newman; TC 1.4 lead with SSPC 135 BACnet and TC4.11 as co-sponsors)	San Francisco, 1/98
Impact of Electromagnetic Interference on Control Systems and Global Standards (Coogan; TC 1.4 lead with TC4.11 and TC 1.9 as co-sponsors)	San Francisco, 1/98
New Platforms and Gateways for Connecting into Building Management Systems (Phelan)	Toronto, 6/98
The Latest Control Communications Technologies (Gartner; TC 1.4 lead with TC4.11 as co-sponsor)	Toronto, 6/98
Customer Experience with Real-Time Pricing Electric Rates (Kintner-Meyer)	Chicago, 1/99
A Peek at a Real BACnet Building... GSA 450 Golden Gate BACnet Pilot Project (Blanc; TC4.11 lead, with TC1.4 co-sponsor)	Seattle, 6/99
State-of-the-Art Control Devices, Sensors, Motors and Intelligent Actuators (Atkinson; TC1.4 lead with TC1.2, SSPC 135 BACnet, and TC4.11 as co-sponsors)	Seattle, 6/99
Practical Experience Using DDC Systems for HVAC Commissioning and Continuing Evaluation (Bridges; TC1.4 lead with TC1.7, TC4.11 and TC9.9 as co-sponsors)	Dallas, 2/00
Deregulation for Dummies (Haiad)	Dallas, 2/00
Evaluating the Benefits of Fault Detection and Diagnostics	Dallas, 2/00

TC Sponsored Forums (past 3 years, present, planned)

Title	Date (Given or Planned)
What Are The Priorities For On-Line HVAC Fault Detection And Diagnosis? (Haves)	Philadelphia, 1/97
Exactly What Do Smart Buildings and Control Systems Mean Today? (Newman and Kelly; TC 1.4 lead with TG4.SBS and TCs 1.5 and 4.6 as co-sponsors)	Boston, 6/97
Occupant Driven Interactive Building Control (Bridges; TG4.SBS lead with TC 1.4 as co-sponsor)	San Francisco, 1/98
Now That We Have the BACnet Standard Protocol, are DDC Programming Language and Application Standards Next? (Nesler; TC 1.4 lead with SPC 135 BACnet and TG4.SBS as co-sponsors)	San Francisco, 1/98
CAB and BACnet Similarities and Dissimilarities (Newman; TC 1.4 lead with SPC 135 BACnet and TC4.11 as co-sponsors)	Toronto, 6/98
How Can We Accomplish Multi-Vendor Interoperability in Existing Facilities? (Coogan; TC1.4 lead with SPC 135 BACnet and TC4.11 as co-sponsors)	Chicago, 1/99
What's ASHRAE's Role in Deregulation? (Blanc)	Seattle, 6/99

Measuring the Benefit of Fault Detection and Diagnostics (Breuker; TC4.11 lead with TC1.4 as co-sponsor)	Seattle, 6/99
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TC Sponsored Public Sessions (past 3 years, present, planned)

Title	Date (Given or Planned)
Designing, Installing or Operating Engineers - Who Will Most Impact New Millenium Facilities? (Gartner; TC1.4 lead, with TC9.9 and TC4.11 as co-sponsors)	Chicago, 1/99

Journal Publications (past 3 years, present, planned)

Title	When published
None	

Minutes summary and activities sheet submitted by: Les Norford, TC4.11 Secretary

TC4.11 Minutes

Seattle: Tuesday, June 22, 1999

Roll Call, Introductions, Announcements, Minutes

Chairman Braun called the meeting to order at 3:30 p.m. He distributed the agenda (the call-to-meeting letter and the agenda are in Appendix A) and then asked for introductions. A roll call showed that nine of 16 voting members were present: Braun, Rossi, Kintner-Meyer, Lomonaco, Haves, House, Breuker, Bridges, and Gartner. Mitchell, Hackner, and Blanc joined the meeting in progress, bringing the total to 12 of 16.

Kelly asked Speich (RAC contact) about the new procedure for establishing ASHRAE's research plan, which involves RTARs (Research Topic Acceptance Requests) in lieu of one-page research-project descriptions. Speich replied that RTARs are optional and that a TC can for the upcoming year continue to submit one-pagers.

Braun announced that ASHRAE has a technical achievement award and that he would accept nominations for this award. It was moved (Bridges) and seconded (House) to accept the minutes from the January 1999 meeting. The motion was approved unanimously.

Braun then reviewed the scope of TC 4.11 and the new subcommittee structure (Appendix B). The Technical Development Subcommittee will focus on component-level activity, the Communications and Integration Subcommittee will concentrate on integration of basic technologies and the Testing and Evaluation Subcommittee will evaluate the performance of new technologies. The new organization worked well at this ASHRAE meeting.

Technical Development Subcommittee (Rossi)

Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers (1043-RP). Hackner and Seem (PMS chair) visited Purdue in May 1999 to review the experimental facility. A thorough literature review is done, the test-rig chiller is nearly ready to go, and dynamic models are under development. The PMS considers progress to be good and the project is on schedule.

Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment (1139-TRP). Bidders were asked to leave the room. Executive session for bidder evaluation is not required but is the prerogative of the chair and Braun chose not to invoke it. Mark Breuker chaired the PES, which included Haves, Mitchell, Katipamula and Braun (standing in for Dexter). Speich (RAC) also attended the PES meeting. The TC voted to recommend to RAC a contractor for 1139-TRP. Braun appointed a PMS: Breuker (chair), Dexter, Mitchell, Haves, Katipamula.

Development and Evaluation of FDD Methods for Chillers. This work statement describes a second-phase project intended to follow 1043-RP. In Phase 1, faults are being identified and experiments with faulty data are being conducted. Comments on the work statement included a recommendation that Phase 2 activity should focus on evaluation of FDD methods that bidders should identify in their proposals, that the goal is to find FDD methods that work, that the project should include a literature review from aerospace and other industries, and that the title is inappropriate for the intended scope of work. Revisions will be made, with Ahmed to help Katipamula, and a vote is expected in Dallas.

Identification of Degradation Fault Levels in Vapor Compression Systems. There has been no progress over the last six months. The subject overlaps a work statement in the Testing and Evaluation Subcommittee, **Quantifying the Benefits of FDD**, and will be folded into that work statement.

Development of FDD for Sensor Failures. Progress is promised for Dallas.

Rossi would like to move ahead on FDD for air-handling units and expects a follow-up to 1020-RP.

The forum Wednesday on quantifying benefits of FDD will address an important topic; the inability of the research community to quantify benefits is affecting research support.

The minutes of the subcommittee meeting are in Appendix C.

Communications and Integration Subcommittee (Kintner-Meyer)

Utility/EMCS Communication Protocol Requirements (1011-RP). PMS chair Norford reviewed the scope and status of the project. The contractors (PNNL and Hypertek) have submitted a draft final report, which has been reviewed and revised. Reviews were provided by PMS members and members of other organizations. The PMS is satisfied with the work. The contractors then presented their work to the TC, covering the four tasks of the project:

1. Characterization of current technology: automatic meter reading (AMR), real-time electricity pricing (RTP), monitoring and load management.
2. Identification of potential services (description, definition, requirements): revenue meter services; quality of service monitoring, pricing information, remote load management, energy-efficiency monitoring, IAQ monitoring, weather reporting, dynamic demand bidding into power exchanges.
3. Development of data and scenario models to accommodate new services: topology-independent messaging and protocol-independent models, many of which were derived from previous work.
4. Recommendations to ASHRAE for future work. ASHRAE's BACnet committee (SSPC 135) should refine and adopt objects and services, including a new BACnet object to represent hierarchical data objects; ASHRAE should collaborate with such related standards organizations as IEEE.

It was moved (Norford) and seconded (Bridges) that TC4.11 approve the final report for 1011-RP, subject to resolution of remaining reviewer comments. Haiad asked about the universality of the real-time electricity pricing (RTP) model developed by the contractors. The contractors responded that many RTP rates were surveyed. The TC voted approval (11-0-1 CV); Kintner-Meyer, a principal investigator, abstained.

Resolving Discrepancies Between Multiple, Hierarchically-Related, FDD Systems. Brambley described the work statement. There were

questions at the subcommittee meeting as to whether the subject is premature but Brambley feels that the work will be useful at the time it is completed. Brambley, in response to a question from Kelly, stated that the work would be accomplished by identifying conflicts and applying conflict-resolution methods. It is not necessary to apply FDD methods, but there is a need to specify outputs of specific diagnosticians and then to apply conflict-resolution methods. Braun asked whether similar work has been done in such other industries as the chemical-process industry and recommended that the project be scaled back to a survey? Breuker urged that the project include more than a literature survey. Brambley will try to scale back to a literature review and scoping study, to define the problem. Next revision of this work statement will be prepared before the Dallas meeting.

Prototyping and Field Testing of Utility-Consumer Information Services. This work statement is intended to implement communications services selected from those identified in 1011-RP. Kintner-Meyer stated that there will be two phases: a lab test with computers as part of Phase 1 and a field test in Phase 2. Kintner-Meyer is seeking input from SSPC 135, the BACnet committee. The secretary will distribute the work statement to SSPC 135 and TC1.4. The final report for 1011-RP will be distributed to SSPC 135 in August, prior to a meeting of BACnet companies in September.

The minutes of the subcommittee meeting are in Appendix D.

Testing and Evaluation Subcommittee (House)

Demonstration of Fault Detection and Diagnostic Methods in a Real Building (1020-RP). This project applies two distinctly different FDD methods to a set of faults introduced in AHUs. Testing on two experimental AHUs is complete, a draft final report has been submitted, and additional testing, intended to be more realistic and more blind, will be conducted over the summer on a third AHU serving occupied areas of the test building. The contractors plan to submit a revised final report September 30, 1999.

It was moved (House) and seconded (Haves) that ASHRAE grant to the contractors a no-cost extension for 1020-RP until February 15, 2000. The motion passed (11-0-0 CV). . Thanks were expressed to the staff (Klaassen and Suby) at the experimental facility, the Iowa Energy Center's Energy Resource Station.

Integrated Control for Building Services (1113-TRP). TC 4.11 recommended a contractor at the Chicago meeting. RAC approved the recommendation but Technology Council turned it down, not seeing a need for the work and in general not favoring surveys. Comments were provided at the subcommittee meeting for a substantially revised work statement. Braun has been asked to write a letter to the Board of Directors, and will do so, expressing concern that Tech Council disapproved this project so late in the review and approval process.

Quantifying the benefits of FDD. House briefly reviewed this topic, still in the early stages of development by Rossi into a work statement. There is a need for heuristics and simulation to establish costs and benefits over a range of operating conditions. The forum of the same topic at this meeting will help shape the work statement.

The minutes of the subcommittee meeting are in Appendix E.

Research Subcommittee (Kelly)

Kelly presented the research plan for the coming year, included in Appendix G and summarized as follows:

Project	Contributors	Status
1. Evaluation of Existing Fault Detection and Diagnostic Methods for Chillers	Srinivas Katipamula	1 st draft of work statement
2. Integrated Control for Building Services	John House R. Kammerud J. Mitchell	TRP Rejected by Tech. Council, TC will rewrite WS
3. Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems	Todd Rossi Mike Brambly	Rewrite draft WS to be a "scoping study"
4. Prototyping and Field Testing of Utility - Consumer Information Services	M. Kintner-Meyer Marty Burns Chuck McParland	1 st draft of work statement

5. Quantifying the Benefits of Fault Detection and Diagnostics	Todd Rossi Mark Breuker Jim Braun	one page description
6. Development of Fault Detection and Diagnostics for Sensor Failures	Arthur Dexter	one page description
7. Multi-Application Comparison of FDD Methods	John House	one page description

It was moved (House) and seconded (Braun) to approve the Long-Range Research Plan. Discussion included the need for new research ideas: multiple faults, testing of additional faults (follow-on to 1020-RP), and commissioning. The motion was approved (11-0-0 CV).

Kelly reported that TC 4.6 is preparing a work statement for dynamic coil models that could be appropriate for controls analysis and FDD. Braun suggested that TC4.11 consider co-sponsorship, when the work statement has been completed and reviewed.

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Program Subcommittee (Lomonaco)

Lomonaco reviewed the program for the Seattle meeting and noted a very positive response to Blanc's forum on deregulation.

Lomonaco presented plans for programs at upcoming meetings. Haves suggested that TC4.11 wait to see what is approved for Dallas and then conduct a letter ballot for Minneapolis, given that the Minneapolis program must be approved before the Dallas meeting. Kelly asked that the program be organized by meeting rather than subcommittee, with subcommittee annotation, to facilitate prioritization.

It was moved (Lomonaco) and seconded (Blanc) to approve the program for Dallas as presented by Lomonaco. The motion passed by unanimous voice vote. Programs as subsequently approved by ASHRAE are tabulated at the beginning of these minutes. Lomonaco did not submit program subcommittee minutes for attachment nor provide the planned program for Minneapolis.

TC 4.11 Web Site

The web site (<http://www.ecw.org/tc411>) is up and running and is connected to ASHRAE's home page. Braun congratulated Hackner for a great job. Hackner was encouraged to post draft work statements. Hackner will also provide mailing lists, via a list server rather than roster list. Kelly noted that minutes include a contact list.

Roster for July 1999 – June 2000

Braun reviewed the new roster. Braun has deleted voting and corresponding members who have not attended. Haves should not be listed as an international member.

Old business

Braun and Blanc offered tribute to Ron Kammerud. Members wishing to offer thoughts to his wife can send email to Kammerud's address.

New business

None.

Adjournment

It was moved (House), seconded (Gartner), and unanimously voted to adjourn at 6 p.m.

Appendices

- A. Call to Meeting and Agenda
- B. Scope and Organization
- C. Technology Development Subcommittee Report
- D. Communications and Integration Subcommittee Report
- E. Testing and Evaluation Subcommittee Report
- F. List of Subcommittee Attendees
- G. Research Plan and Activities

H. Program Subcommittee Report – not provided by subcommittee chair

Appendix A.

Call to Meeting and Agenda

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

1791 Tullie Circle, NE, Atlanta, Georgia 30329-2305 404-636-8400 | Fax 404-321-5478

Reply to: Jim Braun

Ray W. Herrick Labs

Purdue University

W. Lafayette, IN 47907

(jbraun@ecn.purdue.edu)

June 14, 1999

Dear TC 4.11 Member, International Member, or Corresponding Member,

The **TC** on Smart Building Systems and its subcommittees will meet in Seattle according to the following schedule:

TC 4.11 Technology Development Sunday (6/20) 3:00-4:00p CC/205

TC 4.11 Communication & Integration Sunday (6/20) 4:00-5:00p CC/205

TC 4.11 Testing & Evaluation Sunday (6/20) 5:00-6:00p CC/205

TC 4.11 Smart Building Systems Tuesday (6/22) 3:30-6:00p CC/304

Note that the subcommittee names have changed as follows: Technology Development was formerly Fault Detection and Diagnostics, Communication and Integration was formerly Utility- Building Interface, and Testing and Evaluation was formerly Applications.

Also note that some time (e.g., 15 minutes) should be set aside at the end of each subcommittee meeting for program discussions.

The TC is the sponsor or co-sponsor for the following sessions in Seattle:

Seminar 5: A Peek at a Real BACnet Building: The 450 Golden Gate Project,

Sunday, June 20, 1999, 10:15 AM - 12:15 PM

Forum 22: What Is ASHRAE's Role In Deregulation? Monday, June 21, 1999, 11:15 AM - 12:05 PM

Seminar 32: State of the Art Control Devices, Sensors, Motors and Intelligent Actuators, Tuesday, June 22, 1999, 10:15 AM—12:15 PM

Forum 37: Measuring the Benefits of Fault Detection and Diagnosis (FDD), Wednesday, June 23, 1999, 9:00 AM - 9:50 AM

(See the ASHRAE Program Booklet for session locations and to confirm the times.)

Attached is a draft agenda for the full TC 4.11 committee meeting in Seattle. I hope to see you all there.

Jim Braun

Chairman, TC 4.11

ASHRAE TC 4.11

Smart Building Systems
1999 Annual Meeting, Seattle
DRAFT AGENDA

Location: CC/304

Date: Tuesday, June 22, 1999

Time: 3:30 - 6:00 p.m.

1. Roll call and introductions
2. Approval of Minutes from Chicago
3. Announcements
4. Overview of New Subcommittee Structure and Scopes
5. Technology Development Subcommittee Report (Todd Rossi)

1043-RP, Fault Detection and Diagnostic (FDD) Requirements and Evaluation Tools

for Chillers (John Seem)

Select Contractor for 1148-TRP, Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment (Mark Breuker)

Draft Work Statements

Program plans

Other activities

6. Communications and Integration Subcommittee Report (Michael Kintner-Meyer)

Final Report on 1011-RP, Utility/EMCS Comm. Protocol Requirements (Les Norford)

Draft Work Statements

Program plans

7. Testing and Evaluation Subcommittee Report (John House)

1020-RP, Demonstration of Fault Detection and Diagnostic Methods in a Real

Building (John House)

Status of 1113-TRP, Integrated Control for Building Services (John House)

Draft Work Statements

Program plans

Other activities

8. Research Subcommittee Report (George Kelly)

New Work Statements

Approval of 1999 - 2000 Research Plan

9. Program Subcommittee Report (Carol Lomonaco)

Plans for Dallas (1/2000)

Plans for Minneapolis (6/2000)

Plans for future meetings

10. TC 4.11 Website (Rich Hackner)

11. TC 4.11 1999-2000 Roster

12. Additional old business

13. Additional new business

14. Adjournment

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Appendix B.

TC 4.11 Smart Building Systems

Scope and Organization

Overall Committee Scope

The Technical Committee on Smart Building Systems (SBS), TC 4.11, is concerned with the development and evaluation of technologies that could enable the widespread application of smart building systems. "Smart" buildings should take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. This implies integration of building services such as HVAC, fire, security, and transportation; the automation of many of the operation and maintenance functions traditionally performed by humans; and the interaction with outside service providers such as utilities, energy providers, and aggregators. Currently, three subcommittees form the backbone of the TC's activities: technology development, communications and integration, and testing and evaluation. The scope and activities of these subcommittees are defined as follows.

Technology Development Subcommittee

The Technology Development Subcommittee is concerned with research issues associated with the development of emerging smart building

technologies such as (but not restricted to) automated commissioning, performance monitoring, fault detection and diagnosis, optimal maintenance scheduling, and optimal control. The primary outcome of research endorsed by this subcommittee is expected to include data used to justify the development of smart building technologies, data and models that enable development of the technologies, and comprehensive methods that are the basis of the technologies. Specific research topics that are ongoing or planned under this subcommittee are:

- 1043-RP Fault Detection and Diagnostic (FDD) Requirements and Evaluation Tools for Chillers
- Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment
- Development and Evaluation of Fault Detection and Diagnostic Methods for Chillers
- Identification of Degradation Fault Levels in Vapor Compression Systems
- Development of Fault Detection and Diagnostics for Sensor Failures

Communications and Integration Subcommittee

The Communications and Integration Subcommittee is concerned with research issues associated with enabling the seamless interaction of smart building components and services. An important aspect of this work is to identify the information that is necessary to support smart building technologies, and to identify the requirements of communication protocols to support the exchange of this information between different building services, between buildings and utilities, between multiple buildings, with outside service providers, etc. Specific research topics that are ongoing or planned under this subcommittee are:

- 1011-RP Utility/EMCS Communication Protocol Requirements
- Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic (FDD) Systems
- Prototyping and Field Testing of ASHRAE's Utility Consumer Interface Models (UCIM)
- What do vendors want to know about their customers? Needs for, issues about and implications of vendor access to customer data.
- Optimizing EMCS Architecture in BACnet Speaking Systems

Testing and Evaluation Subcommittee

The Testing and Evaluation Subcommittee is concerned with research issues associated with assessing the performance or potential benefits of smart building t

technologies. Research endorsed by this subcommittee is expected to result in data, metrics, methods, and tools/standards/guidelines for quantifying smart building system performance in a standardized manner, as well as findings from the actual application of these metrics, methods and tools. Specific research topics that are ongoing or planned under this subcommittee are:

- 1020-RP Demonstration of Fault Detection and Diagnostic Methods in a Real Building
- 1113-TRP Integrated Control for Building Services
- Methods for Quantifying the Benefits of HVAC Equipment Monitoring and Fault Detection
- Multi-Application Comparison of Fault Detection and Diagnostic Methods

Appendix C.

TC4.11 Technology Development Subcommittee Meeting

Minutes

Seattle: June 20, 1999 3:00-4:00 p.m.

1. Todd Rossi (Chair) began the meeting by distributing and discussing the new structure of the TC 4.11 research subcommittees. Rossi summarized the objectives of the Technology Development Subcommittee as well as the redistribution of work statements.
 2. Jim Braun gave a brief status report on 1043-RP "Fault Detection and Diagnostic (FDD) Requirements and Evaluation Tools for Chillers." The PMS will meet Monday and John Seem (PMS chair) will report more details to the full committee on Tuesday.
 3. Mark Breuker gave a brief update on the status of 1139-TRP "Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment." The PES will meet following the TC 4.11 research subcommittee meeting to consider the proposals and recommend a bidder to the full committee on Tuesday.
 4. Srinivas Katipamula distributed and discussed a draft work statement entitled "Development and Evaluation of FDD Methods for Centrifugal Chillers." This is a follow-up to 1043-RP.
- Jim Braun pointed out that 1043-RP identifies the faults of interest and produces laboratory data. The work statement should be revised to reflect this.
 - George Kelly suggested the evaluation of three methods, with one spelled out in the proposal and two others selected as part of Task 1. Bidders would be expected to describe all methods that they would envision investigating.
 - John Mitchell suggested the project should tie into 1139-TRP "Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment."

- Todd Rossi suggested that Task 1 be revised to require a literature review of how you assess FDD methods – the deliverable would be a separate document. Carlos Haiad suggested this should be a separate task.
 - Les Norford expressed concern over the title – are we developing methods or just evaluating methods. Norford suggested we should use already developed methods and the title should be changed to "Evaluation of FDD Methods for Centrifugal Chillers."
 - Rossi suggested other revisions to strengthen Norford's point, specifically that the "Other Information for Bidders" section should require bidders to specify methods to be used and why.
 - Rossi and Osman Ahmed discussed the purpose of Task 4 – should it recommend an FDD method for chillers, or recommend that this research has produced a method that should be used to evaluate FDD methods.
 - Phil Haves suggested another title change to "Evaluation of Existing FDD Methods for Centrifugal Chillers."
1. Todd Rossi gave a brief overview of additional research topics.

Submitted by John House

Appendix D.

TC4.11 Communications and Integration Subcommittee Meeting

Minutes

Seattle: June 20, 1999 4:00-5:00 p.m.

Chairperson: Michael Kintner-Meyer

Old Business

Michael Kintner-Meyer introduced the scope of the newly restructured subcommittee and clarified the appropriateness of the FDD work statement titled "*Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostics (FDD) Systems.*"

Les Norford reported on the research project 1011-RP titled "Utility/Energy Management and Control System (EMCS) Communication Protocol Requirements". The PMS committee will meet with contractors (Battelle and Hypertek) on the following Tuesday. Expected are some revisions to be

added by contractors. In general, work is in good status.

RESEARCH

Proposed Research Topics:

- Work Statement:

"Prototyping and Testing of Utility/Customer Information Services", Marty Burns, Michael Kintner-Meyer. Michael Kintner-Meyer discussed the workstation prepared by Marty Burns and himself. The scope of the work statement would be an extension of the 1011-RP project and encompasses prototyping, implementation, and field-testing of selected energy-information services defined in 1011-RP. Commercial, industrial, and residential customers could potentially be targets for the services. The work statement discusses Phase I of a two phase project.

In Phase I, selected energy/information services will be designed and implemented on PC and simulated on networked PCs emulating the information exchange among all parties involved (i.e., utilities, ESCO, customer).

Phase II involves the field testing of the technology developed in Phase I.

Cost of the Phase I project is \$140,000 over 12 months.

The ensuing discussion centered on scalability issues and how this would be addressed in the work statement. Utilities would need to deploy information services not to hundreds of thousands but to millions of customers. It was mentioned that the scalability to a large-scale deployment would need to be part of the Phase I tasks. The question arose whether or not BACnet would need to be extended for the implementation of the selected services. Marty Burns responded that extensions to BACnet would not be necessary. Jim Braun raised the question about the appropriateness of the cost for the project. Michael Kintner-Meyer defended the cost estimate and characterized the level of effort and work quality necessary to provide value to ASHRAE.

It was also mentioned that TC 1.4 was co-sponsor of the 1011-RP and whether TC 1.4 would be considered to co-sponsor this work statement. John House responded that no actions have been taken for this work statement to be co-sponsored by TC 1.4. Furthermore, it was suggested that the members of the BACnet standards committee be consulted for their buy-in. Steve Bushby will email the work statement to all BACnet standards committee members and other external people who may have an interest in this subject.

- No progress on the potential topic of "Security issues for encryption and authentication when clients interact over WANS through gateways to LAN". Marty Burns suggested this subject at a previous meeting. No one-pager has been written.

- Work statement

"Resolving Discrepancies Between Multiple, hierarchically-Related FDD Systems". Mike Brambley described the work statement briefly. A discussion about this work statement followed. At issue was the notion that this work statement may be too far ahead of the current state of the technology. FDD is still in its infancy and does not have sufficient tools available that employ various methodologies for the some FDD target problems. It may therefore be premature to define a research topic that investigates potential future discrepancies of FDD systems. Mike Brambley argued that a few FDD systems are already being used and that we ought to be proactive and investigate what potential problems may occur if we are solving FDD problems using different hierarchical concepts in our methodologies. Mike Brambley will distribute copies of the work statement at the full TC 4.11 Meeting for discussion. He also suggested a deadline for comments by July 15th and then vote the work statement up or down via e-mail ballot.

New Business

1. PROGRAM

- Forum at the Seattle Meeting titled "ASHRAE's Roles in Deregulation" (Steve Blanc) was well received
- Carlos Haiad will prepare a seminar for Dallas on the subject of energy efficiency opportunities due to deregulation in California.
- Mike Brambley indicated that he will prepare a seminar on automated pattern recognition using ANN
- Les Norford may be able to talk about load signatures on some later ASHRAE meetings.

1. Research

No new research identified.

2. Industry News.

- Michael Kintner-Meyer introduced Afshin Afshari of Silicon Energy, a software company developing web-based load management programs, and asked him to give a brief overview of what his company is doing and what the industry's vision is for the future on energy/information related products and services. Afshin gave a brief overview of the functionalities of Silicon Energy's platform and indicated that his company sees that there will be a need in the near future for dynamic bidding and sophisticated load management programs. Carlos Haiad mentioned that his company will be performing some dynamic bidding over the web.

Appendix E.

TC4.11 Testing and Evaluation Subcommittee Meeting

Minutes

Seattle: June 20, 1999 5:00-6:00 p.m.

Notes by: Todd Rossi

1. John House reviewed new scope of this subcommittee.
 2. John House reviewed 1020-RP. Project is nearing completion. A draft of the final report has been prepared. Asking of non cost extension until mid February 2000.
 3. John House reviewed work statement "Integrated Control for Building Services". Need to address Tech Counsel's concerns leading to rejection (need not seen, already done by others, and not enough value in survey). Concern about needing a professional (not grad student) to do work.
- Phil Haves suggested that not enough academic benefit to get more than one bidder. Universities were not attracted.
 - Phil Haves suggested that examples might help sell work statement. John House suggested asking facility managers at universities (for example) about the benefits to help sell. Steve Blanc suggested Mike Neuman at Cornell. Carol Lomonico (Abbot), Michael Kittenmeier (Baltimore Aquarium), Mark Breuker have ideas of building facility managers to contact. They suggest getting testimonials to support work statement.
 - Steve Blanc suggested focussing on more specific issues. What are the integration problems? What did you try? What did or didn't it work?
 - John Mitchell asks: What is the next step? Does this depend on the survey results? This may be another to get specific.
 - Steve Blanc committed to sending John House an email with comments to help him move forward.
 - Barry Bridges suggested being more specific by focusing on which systems to integrate (e.g. HVAC and Fire).
 - Phil Haves suggested integrating airborne hazard detectors.
 - Steve Blanc discussed the issues around using standard business LANs for integration (e.g. security).
 - Steve Blanc knows people in the controls industry that pointed out that integration is an upcoming business opportunity.
 - George Kelly asks: Can this be related to BOMA surveys to get wider exposure? Debbie... may know about this.

1. Discussion on Todd Rossi's work statement on quantifying benefits of FDD.

- George Kelly: Look at it with heuristics and simulation.
- Phil Haves: Need to use modeling to extrapolate costs over wide range of conditions.
- John House: Should we work with TC 1.4 recommissioning project?
- Phil Haves asks Rob Pratt about extrapolating cost to one year.
- Cost benefit ratio important.
- Mark Breuker: Work towards this work statement at the Forum on Wednesday.
- Mark Breuker: We may want to role the survey WS he sponsored into this one.
- Phil Haves: Should we develop methods to assess benefits of FDD separate from the FDD methods?
- Rob Pratt: What is the cost of a 3F outdoor air temperature sensor offset.

1. Program – Carol Lomonico

- Michael Brambley suggested forum for Dallas asking: What are ASHRAE members needs and problems with sensors? What technology is out there to solve them? Seminar 32 (Schell) in Seattle addresses these issues?
- "Practical experiences..." Barry Bridges. Seminar for next summer.
- "Is brother watching???" Barry Bridges. Three authors to date. Security or energy issue speaker still needed. More time needed. Minneapolis or Atlanta. Cliff will have no results until next summer. Interest high. Seminar
- "Standard programming languages...BACnet" cosponsor. Clay Nesler and Jim Gartner.

Appendix G

TC 4.11 Smart Building Systems

Research Plan and Activities

July 1999

Research Objectives: The long-term goal of TC 4.11 is to conduct research on topics that will lead to the development and application of "smart"

building systems. "Smart" buildings of the future will take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. A smart building would most likely have fully integrated control of building services such as HVAC, fire, security, and transportation. Integrated systems would reduce initial costs and could be "supervised" so as to meet the primary objectives of comfort, safety, and performance at minimum operating cost. In addition, the integration of the hardware and software for operation and monitoring of equipment would lead to reductions in support staff needs and improved equipment reliability. Further cost reductions and reliability improvements would be possible through the integration of automated techniques for detection and diagnosis of equipment faults. Ultimately, "smart" building systems could facilitate the use of "remote" support staff that operates, monitors, and maintains a number of different buildings from a centralized location. At this higher level, a smart building might communicate and inter-operate with other smart buildings for the purpose of load aggregation and centralized control and with outside service providers, such as utilities, energy providers, aggregators, and newly developing companies providing fault detection, automated commissioning, optimization, and other innovative services. In addition to the savings in operating costs associated with "smart" buildings, other benefits include energy conservation and enhanced occupant safety and comfort.

Several developments are needed before "smart" building systems become a reality. These include demonstrating the benefits of possible features (e.g., system integration, fault detection and diagnostics, load aggregation); developing and demonstrating the communication protocols necessary for different systems and players to communicate (including communications between building systems and utilities); and developing, demonstrating, and evaluating systems for performance monitoring, fault detection, and fault diagnosis of typical equipment and systems.

Current TC 4.11 research includes projects in many of these areas. The evaluation of communication protocol requirements between utilities and energy management systems is being addressed in 1011-RP. Fault detection and diagnostics (FDD) is being considered for a number of different HVAC applications. Demonstration of the performance and benefits of current FDD approaches for air handling systems is being performed as part of 1020-RP. The identification of important faults and their impacts on performance for chillers is being determined in 1043-RP, while the development of on-line training techniques for model-based FDD methods is being carried out in 1139-RP for vapor compression equipment.

TC 4.11, Smart Building Systems

Research Plan and Activities

June 1999

Current Research Projects

1011-RP - Utility/EMCS Communication Protocol Requirements (Final Report approved by

TC 4.11 at Seattle Annual Meeting on 6/22/99.)

1020-RP - Demonstration of Fault Detection and Diagnostic Methods in Real Buildings

1043-RP - Fault Detection & Diagnostic Requirements & Evaluation Tools for Chillers

1139-RP - Development and Comparison of On-line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment

1999-2000 Research Plan

Project	Contributors	Status
1. Evaluation of Existing Fault Detection and Diagnostic Methods for Chillers	Srinivas Katipamula	1 st draft of work statement
2. Integrated Control for Building Services	John House R. Kammerud J. Mitchell	TRP Rejected by Tech. Council, TC will rewrite WS
3. Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems	Todd Rossi Mike Brambly	Rewrite draft WS to be a "scoping study"
4. Prototyping and Field Testing of Utility - Consumer Information Services	M. Kintner-Meyer Marty Burns Chuck McParland	1 st draft of work statement

5. Quantifying the Benefits of Fault Detection and Diagnostics	Todd Rossi Mark Breuker Jim Braun	one page description
6. Development of Fault Detection and Diagnostics for Sensor Failures	Arthur Dexter	one page description
7. Multi-Application Comparison of FDD Methods	John House	one page description

TC 4.11, Smart Building Systems

Research Project Description

Priority 1

Project Title: Evaluation of Existing Fault Detection and Diagnostic Methods for Chillers

Summary: In 1043-RP, the important faults to be considered and the appropriate sensors were identified. In addition, a physical model for simulating chiller behavior was developed to evaluate the effectiveness of the various FDD methods in identifying different faults. In this project, different FDD methods will be implemented and evaluated through the use of simulation. Procedures to evaluate and compare the various FDD methods will be developed. Promising FDD methods will be selected and recommended for future laboratory and field testing.

Objective: Develop procedures for evaluating and comparing different FDD methods for chillers, and assess the performance of the methods through simulation.

Benefits: Automated FDD applied to chillers used in air conditioning of commercial buildings has the potential to reduce energy and maintenance costs and improve comfort and reliability. Although current control systems typically monitor many variables, this information is not used for diagnosing faults. At best, these systems incorporate automatic shutdown procedures that guard against catastrophic failures when measurements are extremely out of range.

Estimated Cost: \$90,000

Estimated Duration: 18 months

Methods of Publishing Results

1. Detailed Reports
2. Technical Paper(s)

Potential Cosponsors:

1. chiller manufacturers
2. chiller service providers

TC 4.11, Smart Building Systems

Research Project Description

Priority 2

Project Title: Integrated Control for Building Services

Summary: The integration of the control of multiple building services, such as HVAC, fire, security, and transportation, offers building owners and operators many benefits and some possible problems. Unfortunately there has been no systematic research to evaluate and document the pros and cons of integration, nor to examine the different methods by which it may be achieved. This study will examine different levels of integration in commercial office buildings, including no integration, the use of a single network by different building systems (token integration), full integration using a building management system from a single vendor, and different vendor supplied building systems using a common communication protocol, such as BACnet. The benefits and problems associated with each approach will be carefully documented. In addition, various performance measures will be developed to compare the safety, reliability, comfort, cost, energy consumption, ease of use, maintenance requirements, etc. of the different approaches.

Objectives:

1. To examine different approaches to the integration of building services in a variety of commercial office buildings.
2. To evaluate and document the pros and cons associated with each approach.
3. To develop performance measures that can be used by building designers, owners, and operators for comparing different levels of integration

and for selecting the best approach for a given application.

4. To develop recommendations for future research in this area.

Benefits: This research will provide valuable information on the benefits and problems associated with the integration of building services. The development of performance measures for comparing different approaches should significantly improve the decision making process for building designers, owners, and operators. In addition, this work is likely to lead to the future development of ASHRAE Guidelines on evaluating and choosing the best approach to integrating building services in different applications.

Estimated Cost: \$50,000

Estimated Duration: 10 months

Methods of Publishing Research Results:

1. Detailed Reports
2. Technical Paper(s)

TC 4.11, Smart Building Systems

Research Project Description

Priority 3

Project Title: Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems

Summary: A variety of different fault detection and diagnostic (FDD) methods have been studied (by IEA Annex 25 and others) and applied to HVAC systems using either simulation or laboratory test rigs. It was found that each of the methods appears to have different strengths and weaknesses. Thus, future FDD systems installed in actual buildings are likely to employ a number of different FDD methods on the same HVAC subsystem, different HVAC subsystems, and at different levels within a building's energy management and control system (EMCS). How the results from all these different FDD applications are coordinated, integrated, evaluated, and how conflicts are resolved and information presented to the operator in an intelligent manner needs to be addressed.

Objectives:

1. Select several promising methods for performing FDD on selective HVAC subsystems
2. Examine different approaches for applying these multiple methods to the same and different subsystems and at different control levels
3. Examine different approaches for coordinating, integrating, evaluating, and presenting the resulting information to the building operator.
4. Evaluate and document the benefits and problems associated with each approach to FDD conflict resolution and recommend one or more preferred distributed/hierarchical FDD architectures for use in HVAC applications.

Benefits: A better understanding of the different approaches for integrating FDD methods in a distributed and hierarchical manner will accelerate the development and implementation of FDD systems in buildings. This in turn should lead to improved HVAC performance, reduced energy consumption, and lower operating and maintenance costs.

Estimated Cost: \$75,000

Estimated Duration: 12 months

Methods of Publishing Research Results:

1. Detailed Reports
2. Technical Paper(s)

TC 4.11, Smart Building Systems

Research Project Description

Priority 4

Project Title : Prototyping and Field Testing of Utility-Consumer Information Services

Summary: ASHRAE is currently funding the research project titled: "Utility/Energy Management and Control System (EMCS) Communication Protocol Requirements" (RP1011). The objectives of RP1011 are: 1) to identify potential new information services that electricity suppliers are likely to offer to their customers and 2) to determine the communication requirements to establish the service provider/customer communication link. To meet these objectives, several information services were defined and their data and communication requirements were discussed and documented in RP1011. For each information service, an object oriented data model is being developed that succinctly conveys the necessary information between the communicating parties. The set of data models is called *Utility Consumer Interface Models (UCIM)*. As a natural extension of RP1011, ASHRAE intends to prototype and test the UCIMs and the communication between a utility partner and end-users under real world conditions

Objectives: To prototype and test the UCIMs and utility/end-user communication, a phased implementation and testing approach is proposed. In Phase I, a prototype of selected information services will be developed and implemented for one commercial/industrial and one residential application. In phase II, small field trials with 5-20 participants consisting of residential and commercial/industrial customers will be conducted. The objective of the field trials is to gain experience in the implementation into a broad scale of customers EMCS systems and to study the performance of UCIM communications in diverse EMCS and SCADA environments. Phase II requires utility participation to deploy the prototype at several customers' sites.

Benefits: This demonstration will benefit ASHRAE by facilitating the clear definition of responsibilities for communications between customer owned automation systems utilizing BACnet and external parties such as utilities, energy service providers, and other third parties. As such it will explore opportunities for utilizing the Internet and information technology in an environment of distributed computation and responsibility.

Estimated Costs: Phase I: ASHRAE: \$140,000

Phase II: ASHRAE: \$25,000

Utility partners: \$300,000

Estimated Duration: Phase I – 12 months

Phase II – 12 months

Potential cosponsors

SSPC 135

TC 4.11, Smart Building Systems

Research Project Description

Priority 5

Project Title: Quantifying the Benefits of HVAC Equipment Monitoring and Fault Detection

Summary: The most significant barrier to market acceptance of HVAC equipment monitoring and FDD tools is the inability to quantify the benefits to a customer. Benefits can be either increased reliability or lower costs, including equipment, energy, and service. Costs are quantified monetarily, but increased reliability is more difficult, but may, for example, be the percent of occupied time at set point. This project will attempt to quantify the

benefits of HVAC Equipment Monitoring and Fault Detection.

Objective: The objective of this research is to develop a tool (or tools) for quantifying the benefits of monitoring and FDD for specific customer. The project's scope may be adjusted in the following ways:

1. Discuss "Tools" versus more basic "Techniques".
2. Cover general techniques for all HVAC equipment or limit to particular types, such as chillers in central plants or rooftop units.
3. The problem can be more specifically defined. The tool could use a model-based approach to calculate costs with and without monitoring and FDD. The models may be typical for a class of building or application or learned for a particular site. The HVAC costs depend on the weather, comfort control strategy, and state of faults. This tool needs a HVAC equipment model with faults, building model, load profile, service profile, and weather information.

Benefits: This research will help overcome the most significant barrier to market acceptance and ultimately research funding for HVAC equipment monitoring and FDD, which may lead to significant increases in reliability and lower operating costs. Impacts include:

1. Increased up time because hard faults are detected faster and performance degradations can be anticipated by observing the trend as they develop.
2. Equipment or first costs will increase because of the introduction of the monitoring equipment.
3. Energy and service cost may increase or decrease because more up time and more awareness of service needs may use more energy and service. Costs may also increase soon after monitoring and FDD is implemented and then decrease after pent up demand for more and better service is satisfied.

Estimated Cost: \$90,000

Estimated Duration: 12 months

Methods of Publishing Research Results:

1. Detailed Reports
2. Technical Paper(s)

TC 4.11, Smart Building Systems

Research Project Description

Priority 6

Project Title: Development of Fault Detection and Diagnostics for Sensor Failures

Summary: The purpose of this research is to develop Fault Detection Diagnostics (FDD) methods for detecting failed sensors of the type that are typically used in HVAC systems, including: temperature sensors, electricity sensors and flow sensors. Examples of known FDD sensors techniques include: high-low limit comparisons, model comparisons, sensor redundancy, and analytical redundancy. This work would be beneficial to implementing Fault Detection Diagnostics that are dependent on the accurate data from a suite of sensors.

Objectives: This objectives of this research include: (1) a thorough literature search into the current methods that are used to detect sensor failures of the type that typically used in HVAC systems, (2) the development of a suite of FDD procedures for HVAC sensors, and (3) the testing and verification of the developed FDD procedures on specially prepared data from sensors that contain known faults.

Benefits: The project will benefit ASHRAE membership as well as the general public as follows:

1. Assist ASHRAE to develop methods to detect fault diagnostics in sensors.
1. Help equipment suppliers as an aid for incorporating FDD techniques into equipment.
2. Encourage the documentation of such methods.
3. Allow ASHRAE to develop more effective training programs for teaching engineers and architects how to apply FDD methods to sensors.
4. Improving energy efficiency by providing ASHRAE members with improved methods for sensor FDD.

Estimated Cost: \$75,000

Estimated Duration: 18 months

Methods of Publishing Research Results:

1. Detailed Reports
2. Technical Paper(s)

TC 4.11, Smart Building Systems

Research Project Description

Priority 7

Project Title: Multi-Application Comparison of FDD Methods

Summary: One of the challenges of developing a fault detection and diagnostic (FDD) method is the question of how the method should be tested and evaluated. Simulation testing is necessary and beneficial; however, by itself, simulation testing can not adequately evaluate the performance of an FDD method. A standardized testing procedure and performance indices that utilized accepted simulation data sets as well as laboratory/real building data sets would provide developers of FDD methods with a common approach for assessing FDD method performance. ASHRAE 1020-RP and 1043-RP will produce well-documented data sets containing normal and faulty data obtained from two air-handling units and one chiller. This data along with validated simulation data would be used to assess existing FDD methods in different application areas in order to identify the performance of the methods.

Objectives: The objectives of this research are:

1. To develop a standard testing procedure and standard performance indices that can be used to assess the performance of FDD methods;
2. To assess a number of existing FDD methods for different applications to identify the strengths and weaknesses of each method.

Benefits: FDD methods have the potential to increase building energy efficiency, improve comfort and productivity, and prolong equipment life. However, poorly designed FDD methods can lead to false alarms that are also costly. Standardized testing procedures and performance indices are needed to assist developers of FDD methods in the task of testing and assessing these methods in order to produce improved FDD tools. These procedures and performance indices would also provide building owners and operators with a means of assessing the basic capabilities of the methods.

Estimated Cost: \$75,000

Estimated Duration: 18 months

Methods of Publishing Research Results:

1. Detailed Reports
2. Technical Paper(s)

Appendix F.

List of Subcommittee Attendees

Seattle: June 22, 1999

Name	Technology Development	Communications and Integration	Testing and Evaluation
Members (through 6/99 meeting)			
Jim Braun	x	x	x
Todd Rossi	x	x	x
John Mitchell	x	x	x
Michael Kintner-Meyer	x	x	x
Carol Lomonaco	x	x	x
Arthur Dexter			
Philip Haves	x	x	x

Rich Hackner		x	x
John House	x	x	x
Steve Blanc	x	x	x
Mark Breuker	x	x	x
Barry Bridges		x	x
Jim Gartner			
Jeff Haberl			
Ron Kammerud			
Doug Nordham			
Patrick O'Neill	x		
Corresponding members			
Les Norford	x	x	x

George Kelly	x	x	x
Mark Bailey			
Dale Hitchings			
Natascha Castro	x	x	x
Kirk Drees			
Tom Engbring			
Ira Goldschmidt			
J. Carlos Haiad	x	x	x
David Kahn			
Brian Kammers	x	x	x
Curt Klaassen	x	x	x
Ron Nelson	x		

Barry Reardon			
Tim Ruchti			
Greg Schoenau			
John Seem			
Peter Simmonds			
Meli Stylianou			
James Winston			
Visitors			
Afshin Afshari		x	
Osman Ahmed	x		
Kim Barker	x	x	x
Mike Brambley	x	x	x

Dave Branson	x	x	x
Marty Burns	x	x	x
Kevin Cooney	x		
Zulfi Cumali	x	x	
Cliff Federspiel	x		
Srinivas Katipamula	x	x	x
Rob Pratt	x	x	x
Albert Putnam		x	x
Agami Reddy		x	x
Jeff Rutt	x	x	
Jonathan West	x	x	x